

## ADVANCED SPACE TRANSPORTATION TECHNOLOGIES

by

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A wide range of propulsion technologies for space transportation has been discussed in the literature [1, 2]. It is clear from the literature review that a single propulsion technology cannot satisfy the many mission needs in space. Space missions may involve the following: (1) seed life and create a limited environment, (2) transport cargo to sustain life in space or on other planets, (3) manned missions from one planet to another, (4) unmanned missions for deep space exploration of our own galaxy and other galaxies, and (5) set up of special purpose industries. There is a broad spectrum of possibilities which could be outlined. However, a national agenda can only determine the long term goals. The time frame to achieve the tasks of the each goal and the financial commitment require not only the scientific and technological commitment but also the public consensus. Is the final goal of space missions to save and preserve the human race from some catastrophic event, to bring more prosperity, or both? If we indeed find life on another planet, how will our long term goals and agenda change?

Many of the technologies tested, proposed, or in experimental stages relate to: (1) chemical and nuclear fuel, (2) radiative and corpuscular external energy source, (3) tethers, (4) cannons, and (5) electromagnetic acceleration. The scope and limitation of these technologies is well tabulated in the literature [1, 2]. Prior experience has shown that an extensive amount of fuel needs to be carried along for the return mission. This requirement puts additional constraints on the lift off rocket technology and limits the payload capacity. Consider the possibility of refueling in space. If the return fuel supply is guaranteed, it will not only be possible to lift off more payload but also to provide security and safety of the mission. Exploration to deep space where solar sails and thermal effects fade would also be possible. Refueling would also facilitate travel on the planet of exploration. This aspect of space transportation prompts the present investigation.

It is known [3] that about one million tons of hydrogen leaves the Sun every second in the highly ionized form of protons and electrons. The protons and electrons stay apart due to the very high temperature. These particles travel at an average speed of 10 to 20 km/sec from the Sun and accelerate up to speeds of 400 to 3000 km/sec with an average density of 5 to 20 particles/cm<sup>3</sup>. The density and speed of the particle emission from the Sun's corona are dependent upon the various phenomena taking place at the Sun. These phenomena also determine the activity of the Sun. These phenomena are: sunspots, flares, plagues, prominences, coronal holes, etc. [4].

The speed of the particles from corona to planets is treated as a hydro-dynamic phenomenon by Parker [5], who named the flow solar wind. The flow of solar wind particles to various planets is fluid in nature, and it varies depending upon the atmospheric conditions and magnetic field of the

planet. It may be fully absorbed by a body such as the moon, it may be slowed down and deflected by a planet such as the Earth, or it may be partially deflected and partially absorbed by a planet such as Mars. The solar wind will also exert pressure on the planet's atmosphere. The solar wind may get trapped in some parts of space and retained there due to the presence of electric or magnetic fields.

The author proposes to collect the particle emissions from the Sun's corona under three different conditions: (1) in space closer to the Sun, (2) in the Van Allen Belts, and (3) on the moon. The author will propose to convert the particle state into gaseous, liquid, or solid state and store it for refueling space vehicles. These facilities may be called space pump stations and the fuel collected as space fuel. The collected fuel will be approximately 90 percent hydrogen, 9.5 percent helium, and the remaining other elements. The three conditions mentioned above provide the best possible sites for collection of space fuel. The methods of collection and subsequent processing, however, will vary. The author is concentrating his efforts in this direction. Preliminary estimates of fuel collection at all three sites will be made. Future work will continue towards advancing the art of collection rate and design schemes for pumping stations.

#### References

1. "Advanced Propulsion Systems Concepts for Orbital Transfer," Boeing Aerospace Company, Seattle, Washington, TR D180266802, 1981.
2. "High-Leverage Space Transportation Technologies," J. Martin, Technical Presentation, NASA, Washington D.C., Sept. 23, 1986.
3. "Frontiers in Astronomy," Reading from Scientific American, W. H. Freeman and Company, San Francisco, 1970.
4. "Introduction to Solar Wind," John C. Brandt, W. H. Freeman and Company, San Francisco, 1970.
5. "Interplanetary Dynamical Processes," E. N. Parker, Interscience Publishers, N.Y., 1963.